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Chaon et al.

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(54) **SWEEP CONVEYOR FOR REMOVAL OF GRAIN AND OTHER MATERIALS FROM BINS**

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B65G 19/04 (2006.01)
(Continued)

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CPC ***B65G 19/08*** (2013.01); ***B65G 19/04*** (2013.01); ***B65G 19/22*** (2013.01); ***B65G 65/06*** (2013.01); ***B65G 65/425*** (2013.01)

(58) **Field of Classification Search**
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USPC 198/519, 520, 522, 550.1, 550.4, 198/550.12, 728–734, 735.1, 735.6; 414/309, 327, 306, 322
See application file for complete search history.

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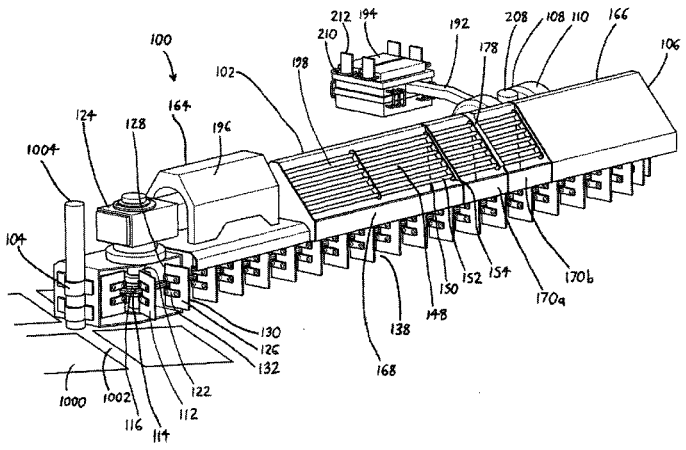
(57) **ABSTRACT**

A sweep conveyor extends along a bin floor between a sump pivot about which the conveyor rotates, and an outer end adjacent the bin wall. During the conveyor's orbit about the floor, flights at the conveyor bottom sweep across the floor toward the sump pivot, whereby bin material in front of the conveyor is swept into a sump. The conveyor is preferably made in modular sections connected end-to-end, whereby different sections are combined to construct conveyors having different lengths and capabilities. Some sections are preferably hinged together, allowing different sections to adopt different inclinations as they travel about a non-level floor. The flights are preferably provided on a belted chain riding on sprockets at opposite ends of the conveyor, and the chain is not supported by idler sprockets along its length, allowing the chain (and its flights) to sag under gravity so the flights ride along the bin floor.

25 Claims, 4 Drawing Sheets



(51) **Int. Cl.**

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B65G 65/42	(2006.01)
B65G 19/22	(2006.01)

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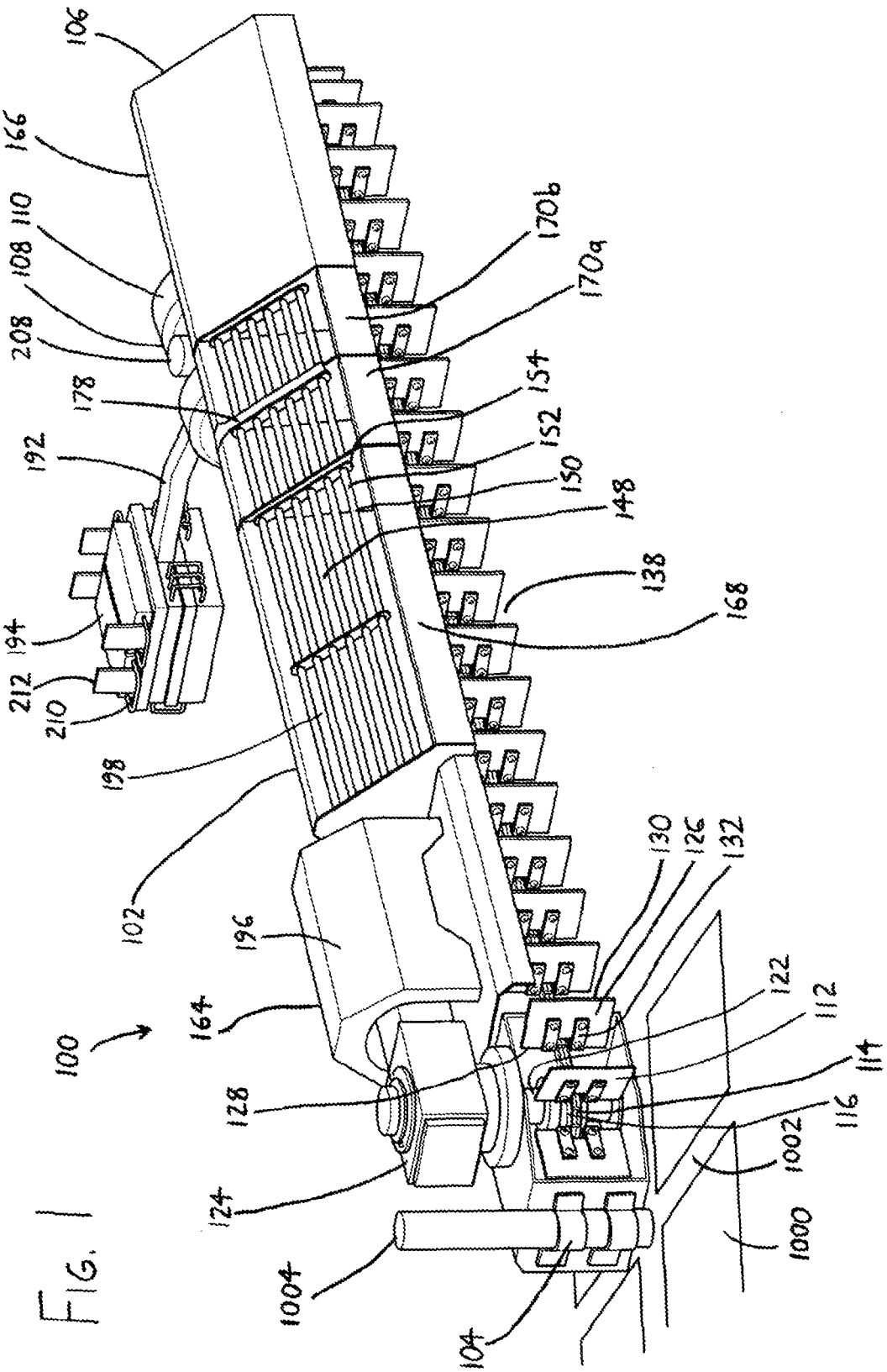
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FIG. 1

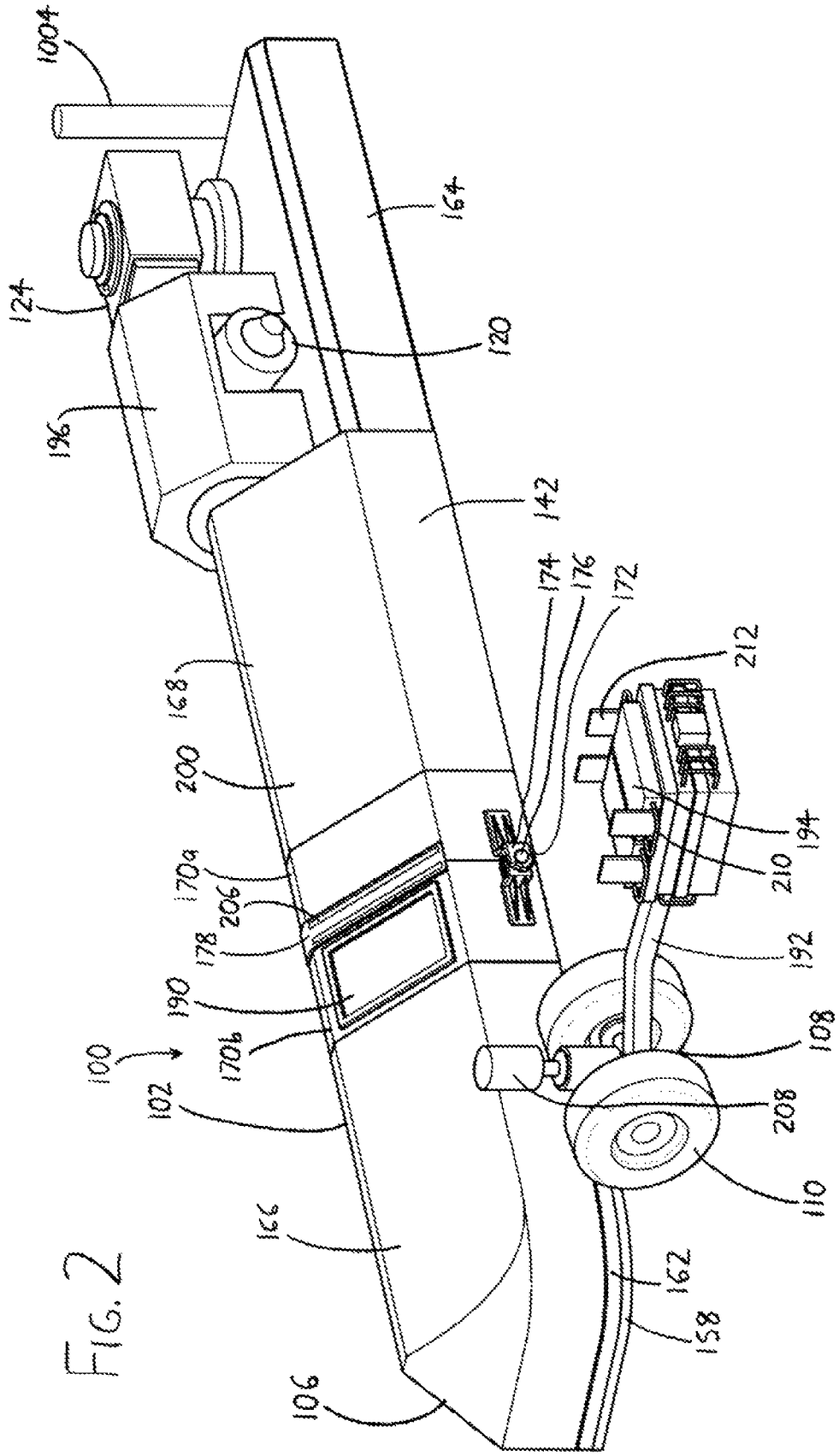
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FIG. 2

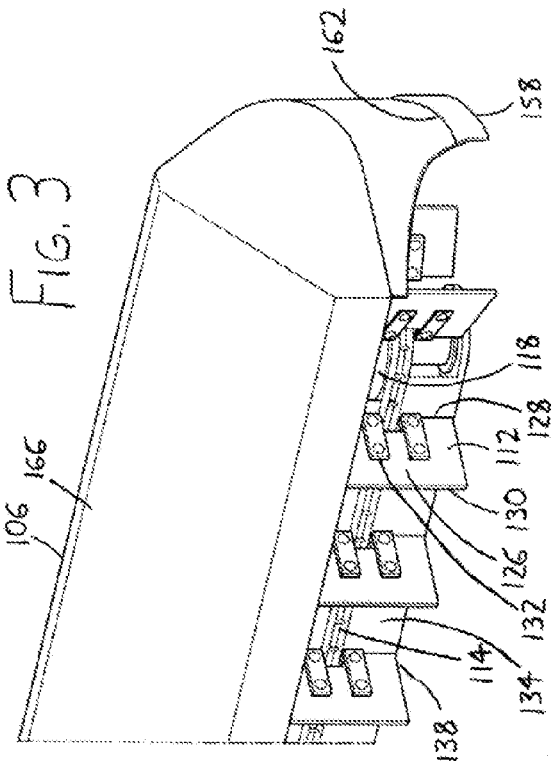
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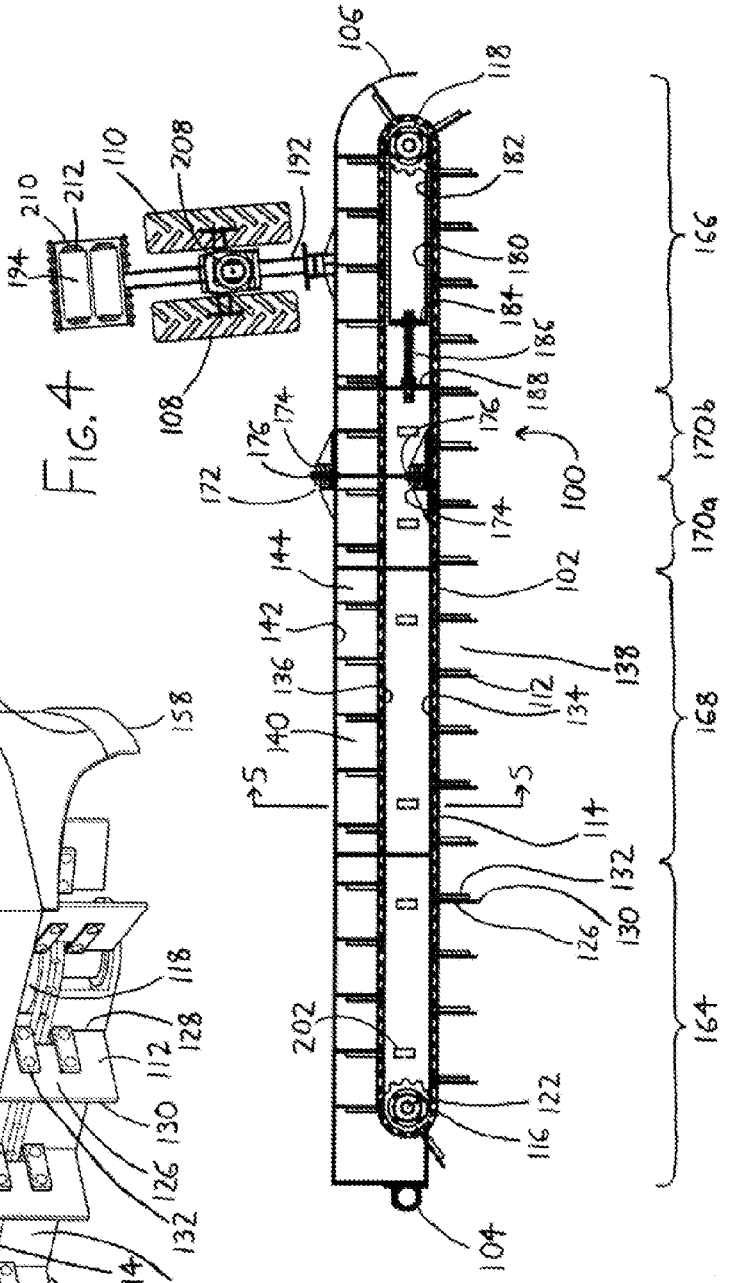
FIG. 3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170b
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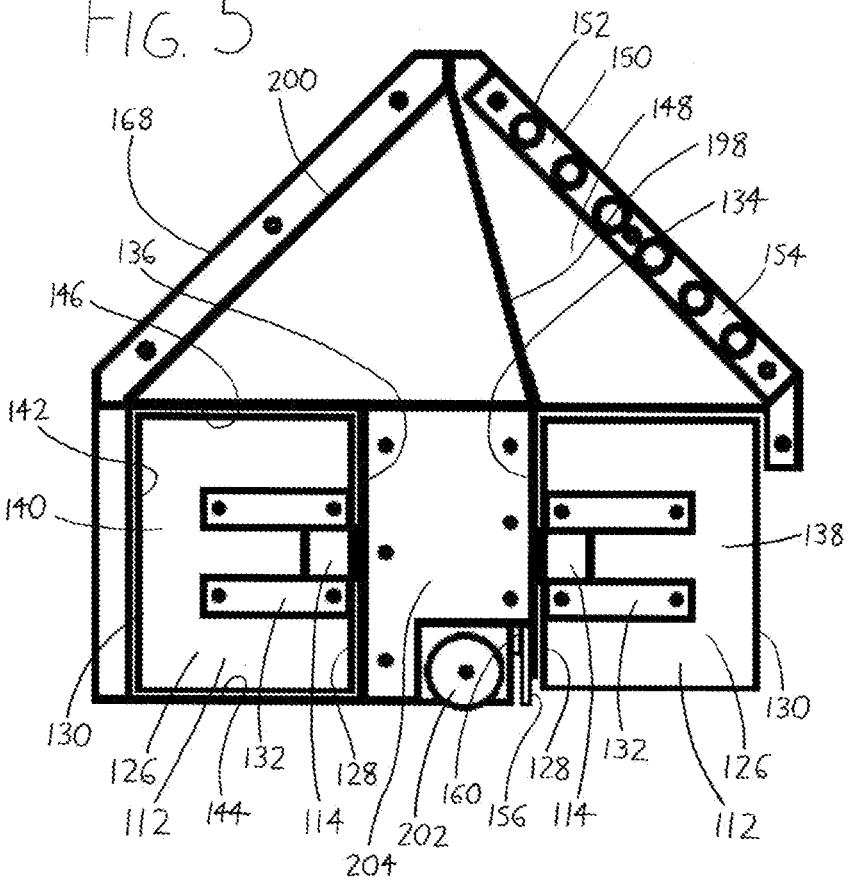
FIG. 4

FIG. 5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SWEEP CONVEYOR FOR REMOVAL OF GRAIN AND OTHER MATERIALS FROM BINS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation under 35 USC §120 of U.S. patent application Ser. No. 13/654,774 filed Oct. 18, 2012 (now U.S. Pat. No. 8,770,388), which in turn claims priority under 35 USC §119(e) to U.S. Provisional Patent Application 61/548,884 filed Oct. 19, 2011. The entireties of these prior applications are incorporated by reference herein.

FIELD OF THE INVENTION

This document concerns an invention relating generally to devices for removing grain and other particulate and/or pulverulent materials from storage bins (silos, tanks, etc.), and more specifically to conveyors used for such purposes.

BACKGROUND OF THE INVENTION

Sweep conveyors are often used to remove grain (wheat, corn, etc.) from grain bins, or otherwise remove loose material from other types of bins (e.g., wood pellets from storage silos, sand or aggregate from holding pens, etc.) The conveyors move about the floor of the bin, typically by rotating about a pivot situated at the bin's center, and engage the material and convey it to a bin outlet, often a sump (pit) leading to a chute or the like from which trucks, rail cars, etc. can receive the material. The conveyors thereby "sweep" the bin and remove the material therefrom. Sweep conveyors of this nature are typically of the screw auger type, wherein a rotating screw engages and conveys the material, or the flighted belt type, wherein flights on a moving belt engage and convey the material (with the flights taking the form of paddles/fins, rakes/tines, or other protrusions which are typically designed to enhance transport of the material being swept). Examples of sweep conveyors of the auger type can be found in (for example) U.S. Pat. No. 4,063,654 to Shivvers; U.S. Pat. No. 4,655,666 to Cantenot; U.S. Pat. No. 4,875,820 to Lepp el al.; U.S. Pat. No. 6,039,647 to Weikel; U.S. Pat. No. 6,095,742 to Campbell; U.S. Pat. No. 6,254,329 to Sukup et al.; U.S. Pat. No. 6,948,902 to Hanig; and U.S. Pat. No. 7,004,305 to Schaefer. Examples of sweep conveyors of the flighted belt type can be found in (for example) U.S. Pat. No. 3,229,665 to Baltz; U.S. Pat. No. 3,338,636 to Chapman el al.; U.S. Pat. No. 3,443,700 to Cymara; U.S. Pat. No. 3,455,470 to Kanagy el al.; U.S. Pat. No. 3,472,357 to Strocker, U.S. Pat. No. 4,516,898 to Cantenot; U.S. Pat. No. 4,762,220 to Lutke; and U.S. Pat. No. 6,499,930 to Dixon.

SUMMARY OF THE INVENTION

The invention, which is defined by the claims set forth at the end of this document, is directed to sweep conveyors which at least partially alleviate problems in the prior sweep conveyors, and/or which otherwise improve on the prior sweep conveyors in one or more respects. A basic understanding of some of the features of exemplary versions of the invention can be attained from a review of the following brief summary of the invention, with more details being provided elsewhere in this document. To assist in the reader's understanding, the following summary occasionally makes reference to selected ones of the accompanying drawings (which are briefly reviewed in the "Brief Description of the Drawings" section following this Summary section of this document), though it should be understood that the noted features may be shown in drawings other than those noted. Since the following discussion is merely a summary, it should be understood that more details regarding the exemplary versions may be found in the Detailed Description set forth elsewhere in this document. The claims set forth at the end of this document then define the various versions of the invention in which exclusive rights are secured.

The drawings (see particularly FIG. **1**) illustrate an exemplary sweep conveyor **100** including a conveyor body **102** having a conveyor length extending between a conveyor sump pivot **104** and a conveyor outer end **106**. The conveyor body **102** rotates about the conveyor sump pivot **104** as it is driven about the floor of a bin (e.g., a grain bin, not shown), and the conveyor outer end **106** travels next to the wall of the bin (where a circular bin is used) as the conveyor body **102** is rotationally driven. A tractor unit **108**, here shown situated at the rear of the conveyor body **102**, has wheels **110** which drive against the bin floor to urge the conveyor body **102** forwardly. (Rollers situated below the conveyor body **102**, discussed below, can also help support the conveyor body **102** during its travel about the bin.) During the orbit of the sweep conveyor **100** about the bin floor, flights **112** (here shown as paddles/fins) situated at the bottom of the sweep conveyor **100** sweep across the bin floor toward the conveyor sump pivot **104**, whereby grain situated within the bin in front of the sweep conveyor **100** is swept into a sump **1000** (which, in a grain bin, is typically a pit having a passage to the outside of the bin). A "spider" **1002**—a set of struts—typically supports a stanchion/pin **1004** or other structure above the sump **1000**, with the conveyor sump pivot **104** being shown as a bearing rotationally fit about this structure. (The sump **1000**, spider **1002**, and stanchion **1004** are shown only in FIG. **1** for sake of simplicity.)

The flights **112** travel on an endless belt **114** (depicted as a chain belt) which rides on an inner wheel **116** at or adjacent to the conveyor sump pivot **104**, and on an outer wheel **118** (FIG. **3**) at or adjacent to the conveyor outer end **106** (with the wheels **116** and **118** being shown as sprockets), with both wheels **116** and **118** being oriented to rotate about at least substantially vertical axes. A motor **120** (FIG. **2**) drives the shaft **122** (FIG. **1**) of the inner wheel **116** via an intervening gearbox **124**. As best seen in FIG. **3**, each flight (paddle) **112** is preferably formed of a plate **126** of flexible material (e.g., reinforced rubber) having a length extending horizontally between a flight inner end **128** at which the flight **112** is affixed to the belt **114**, and an opposing flight outer end **130**. Each flight **112** is affixed to the belt **114** via one or more rigid legs **132** extending outwardly from the (chain) belt **114** near the middle of the flight's height, with the rigid leg(s) **132** extending toward the flight outer end **130** for a major portion of the length of the flight **112**. As a result, each flight **112** is rigid for a major portion of its length extending from the flight inner end **128**, and is flexible along its flight outer end **130**, as well as along its top and bottom. The flights **112** can thereby yield somewhat if they scrape against the floor of the bin, and/or against surrounding portions of the conveyor body **102**, while at the same time having sufficient rigidity that they do not buckle under heavy loads of grain.

A forward inner wall **134** (FIG. **3**) is situated behind the flights **112** near the bottom front of the conveyor body **102**, and a rearward inner wall **136** (FIG. **4**) is similarly situated inwardly from the flights **112** at the bottom rear of the conveyor body **102**. The belt **114** rides on the inner and outer wheels **116** and **118** about the forward and rearward inner walls **134** and **136**, with the space defined in front of the

forward inner wall **134** defining a sweep area **138** (FIG. **1**) where grain is engaged by the flights **112** and swept toward the sump **1000**. The space defined rearwardly of the rearward inner wall **136** defines a return area **140** (FIG. **4**) where the flights **112** leaving the sump **1000** travel toward the conveyor outer end **106** to reenter the sweep area **138**. The return area **140** is bounded by a rearward outer wall **142** (FIG. **2**) spaced from the rearward inner wall **136**, such that the flights **112** traveling in the return area **140** have their flight outer ends **130** sweep closely adjacent to (and/or against) the rearward outer wall **142**. Preferably, a major portion of the return area **140** from the conveyor sump pivot **104** (FIG. **1**) to a location near the conveyor outer end **106** is also bounded at its bottom by a rear floor **144** (FIG. **5**) extending between the rearward inner and outer walls **136** and **142** beneath the flights **112**, thereby deterring grain that failed to fall into the sump **1000** (FIG. **1**) from being redeposited onto the bin floor as the flights **112** travel through the return area **140**. A roof **146** (FIG. **5**) is also preferably provided over at least the return area **140** for similar reasons.

Chutes **148** (FIG. **1**) are defined in the top front of the conveyor body **102** above the sweep area **138** such that grain atop the top front of the conveyor body **102** can fall into the chutes **148**, and thereby into the sweep area **138** for removal. Each chute **148** preferably bears a grating **150** which extends forwardly above the sweep area **138**, with each grating **150** being shown as a set of parallel spaced bars **152** which extends forwardly above the sweep area **138** (with the spacing between the bars **152** being such that grain can readily fall through the bars **152**). The grating bars **152** have endplates **154** at their opposing ends so that the bars **152** can conveniently be installed and removed as a unit for maintenance of the sweep conveyor **100**, e.g., to obtain top access to the flights **112** and belt **114**. The gratings **150** allow the flights **112** to more speedily remove material when the sweep conveyor **100** is driven into taller piles of material, such as those near the perimeter of a grain bin away from the sump **1000**, and/or at the mound of grain that can arise at a location where grain is poured into a bin. The gratings **150** also help to deter large clumps of material from entering the sweep area **138**, at which point they can be swept to the sump **1000**, where they may clog it. Instead, the bars **152** of the gratings **150** tend to break up such clumps owing to the weight of the grain pressing such clumps against the bars **152**, as well as owing to the vibration of the bars **152** during operation of the sweep conveyor **100**. Beneficially, the gratings **150** allow grain to pass through the height of the conveyor body **102**, reducing the weight of the grain on the conveyor **100** when it rests beneath a pile of grain, and allowing the grain to partially support the conveyor body **102**. The gratings **150** additionally provide some degree of safety in case an operator is within a bin during operation of the sweep conveyor **100** (which is not recommended practice), as the bars **152** deter an operator's stepping into the sweep area **138**. The illustrated barred configuration for the gratings **150** is preferred, as the bars **152** add stiffness to the conveyor length (particularly when oriented parallel to the conveyor length).

The conveyor body **102** also preferably includes one or more flexible (e.g., reinforced rubber) flanges extending downwardly along the conveyor length below the conveyor body **102**, whereby as the conveyor body **102** travels along a floor, the flanges ride along the floor to further sweep and collect grain that was not driven into the sump **1000** by the flights **112**. Such "wiper" flanges preferably include flanges **156** (FIG. **5**) descending from the forward inner wall **134**, i.e., at the rear side of the sweep area **138**, as well as flanges **158** (FIG. **2**) descending from the rearward outer wall **142** at the conveyor outer end **106** (where the return area **140** lacks a floor at the exit of the return area **140**). The flanges **156** and **158** are preferably mounted by sandwiching them against the rear side of the forward inner wall **134**, and against the rear side of the rearward outer wall **142**, by elongated plates **160** (FIG. **5**) and **162** (FIG. **2**) which are bolted or otherwise adjustably affixed to these walls **134** and **142**. Such an arrangement allows a flange **156**/**158** to be raised or lowered as desired by loosening the plate **160**/**162**, adjusting the height of the flange **156**/**158**, and then tightening the plate toward the wall **134**/**142**.

The conveyor body **102** is also preferably formed in modular body sections which are adjacently arrayed along the conveyor length, with each body section including a portion of the sweep area **138** (adjacent a portion of the forward inner wall **134**), and a portion of the return area **140** (between a portion of the rearward inner wall **136** and a portion of the rearward outer wall **142**). Different types and numbers of sections can then be combined to construct sweep conveyors having different lengths and capabilities, and sections can also be easily removed for repair and replacement. As seen in FIGS. **1**-**2**, the sweep conveyor **100** includes five body sections: an inner body section **164** bearing the conveyor sump pivot **104**, inner wheel **116**, gearbox **124**, and motor **120**; an outer body section **166** at the conveyor outer end **106**, which bears the outer wheel **118**; and one longer (e.g., 5-8 ft.) intermediate body section **168** and a pair of shorter (e.g., 2-4 ft.) intermediate body sections **170***a* and **170***b* (collectively **170**), each of which bears the aforementioned bars **152**. These intermediate body sections **168**/**170** may be provided in different numbers to construct sweep conveyors of different lengths, with a belt **114** being sized to fit about the inner wheel **116** (FIG. **1**) of the inner body section **164** and the outer wheel **118** (FIG. **3**) of the outer body section **166**. An inner body section **164** with an appropriately-sized motor **120** (FIG. **2**) can be chosen to drive the belt **114**. Different body sections may also be specially configured to meet special objectives, depending on the application for which the sweep conveyor **100** is to be used. For example, in grain bin applications, grain near the bin perimeter tends to clump at the bottom of the bin owing to condensation and possible water ingress into the bin. Thus, it can be beneficial to omit any rear floor **144** (FIG. **5**) beneath the return area **140** of the outer body section **166** (see particularly FIG. **3**), so that the flights **112** in both the sweep and return areas **138** and **140** of the outer body section **166** can scrape at clumped material to better remove it from the bin.

While adjacent body sections can simply be bolted or otherwise affixed together, at least some of the adjacent body sections are preferably hingedly connected such that they may pivot with respect to each other in vertical planes (i.e., adjacent body sections can deviate from the horizontal plane). This arrangement allows the conveyor body **102** to flex along its length if different body sections encounter different floor heights. In FIGS. **2** and **4**, a hinge **172** is situated between the shorter intermediate body sections **170***a* and **170***b*, such that the shorter intermediate body sections **170***a* and **170***b* in combination might be regarded as a hinged body section **170** which flexes along its length. The hinge **172** includes a set of hinge plates **174** connected to the rearward outer walls **142** of the body sections **170***a* and **170***b* outside the return area **140**, as seen in FIGS. **2** and **4**, with the hinge plates **174** being pivotally pinned together; and a similar set of hinge plates **174** connected to the forward inner walls **134** of the body sections between the forward and rearward inner walls **134** and **136**, as seen only in FIG. **4**, with the hinge plates **176** being pivotally pinned together. These hinge plates **174** are shown in the form of sets of ears extending from each of the shorter body sec-

tions **170***a* and **170***b* to rest in parallel adjacent relationship, with a pair of ears on each shorter body section **170***a* and **170***b* receiving an ear of the other shorter body section therebetween, and with a pin **176** extending between the ears to pivotally fix them together. Away from the hinge **172**, the shorter body sections **170***a* and **170***b* have sufficient space between their adjacent ends that the hinge **172** allows (for example) as much as five degrees of variation of one of the body sections **170***a* and **170***b* with respect to the other. The hinge **172** may also (or alternatively) include lengths of flexible barrier material joined between the body sections **170***a* and **170***b*, with FIGS. **1-2** illustrating a rubber strip **178** which extends between the adjacent ends of the body sections **170***a* and **170***b* from their top rear sides to their top front sides (with plates **206**, FIG. **2**, and **154**, FIG. **1**, sandwiching the strip **178** against the end of each body section **170***a* and **170***b*). The barrier material **178** helps avoid the passage of grain through the space between the adjacent ends of the body sections **170***a* and **170***b*, while at the same time also allowing pivoting between the body sections **170***a* and **170***b*.

To allow adjustment of the tension of the belt **114** bearing the flights **112**, at least one of the body sections bearing one of the belt-carrying wheels bears a tensioner which carries one of the wheels thereon, and which is movable along the conveyor length to adjust the tension in the belt **114**. FIG. **4** illustrates a tensioner **180** formed as an elongated rectangular box or beam fit between the forward and rearward inner walls **134** and **136** of the outer body section **166**, and having a tensioner wheel end **182** bearing the outer wheel **118**, and an opposing tensioner adjustment end **184**. A screw **186** extends between and engages the tensioner **180** and the outer body section **166** (at a threaded aperture on a bridge **188** extending between the forward and rearward inner walls **134** and **136** of the outer body section **166**). By turning the end of the screw **186** (which can be accessed from the door **190** situated at the top rear side of the adjacent shorter intermediate body section **170***b*), the tensioner **180** (and thus the outer wheel **118**) is urged along the length of the outer body section **166**, thereby allowing modification of the tension of the flight-bearing belt **114**.

As best seen in FIGS. **2** and **4**, the tractor unit **108** is shown situated on a tractor arm **192** extending from the rearward outer wall **142** of the outer body section **166**, though the tractor unit **108** could be situated on other body sections instead (and/or additional tractor units **108** can be situated on other body sections). Preferably, at least one tractor unit **108** is situated along the conveyor length at a location closer to the conveyor outer end **106** than the conveyor sump pivot **104**, since tractor units **108** situated closer to the conveyor outer end **106** can more efficiently drive the conveyor body **102** forwardly. The tractor unit **108** is preferably connected to the conveyor body **102** to pivot about an axis oriented at least substantially perpendicularly to the conveyor length, as by providing a bearing along the tractor arm **192**. Such an arrangement better allows both wheels **110** of the tractor unit **108** to remain on (and drive against) the bin floor when the floor is not level. To provide the tractor unit **108** with better traction on the floor, it may be weighted, with FIGS. **1-2** and **4** showing a set of weights **194** situated atop the tractor unit **108** (with these weights **194** being removable and replaceable so that a user may weight the tractor unit **108** as desired).

Further advantages, features, and objects of the invention will be apparent from the remainder of this document in conjunction with the associated drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a front perspective view of an exemplary sweep conveyor **100** as discussed above, with the sweep conveyor **100** rotating about the conveyor sump pivot **104** on the bin floor (not shown), and with its flights **112** sweeping inwardly toward the sump **1000** such that grain encountered during the travel of the conveyor **100** is swept into the sump **1000**.

FIG. **2** is a rear perspective view of the sweep conveyor **100** shown without the sump **1000** of FIG. **1**.

FIG. **3** is a front perspective view of the outer end **106** of the outer body section **160** of the sweep conveyor **100** of FIGS. **1-2**.

FIG. **4** is a simplified schematic top cross-sectional view of the sweep conveyor **100** of FIGS. **1-3** taken along a horizontal plane situated approximately halfway up the heights of the flights **112**, but schematically illustrating the tractor unit **108** from its top (without sectioning).

FIG. **5** is a simplified schematic cross-sectional view of the longer intermediate body section **168** of the sweep conveyor **100** of FIGS. **1-3**, taken along the vertical plane **5-5** illustrated in FIG. **4**.

DETAILED DESCRIPTION OF PREFERRED VERSIONS OF THE INVENTION

Expanding on the discussion above, the conveyor body **102** will typically rest on the floor of a grain bin or the like, and will often be wholly or partially buried in grain poured atop it within the bin. The conveyor body **102** is driven by the tractor unit **108** to rotate (in a clockwise direction in FIG. **1**) about the conveyor sump pivot **104**. During such rotation, the motor **120** (FIG. **2**) drives the inner wheel **116** (FIG. **1**), and thus the belt **114** and flights **112** thereon, so that the flights **112** in the sweep area **138** are driven inwardly toward the sump **1000**. Grain can enter the sweep area **138** both from the bottom front of the conveyor body **102** (i.e., in front of the flights **112** as the conveyor body **102** is driven forwardly by the tractor **108**), and also by falling into the chutes **148** defined beneath the bars **152** in the intermediate body sections **168**, **170***a*, and **170***b*, to be swept by the flights **112** into the sump **1000**. The flange **156** (FIG. **5**) situated at the bottom of the forward inner wall **134**, and the flange **158** (FIGS. **2-3**) at the rearward outer wall **142** of the outer body section **166**, assist in collecting any residual grain that isn't swept by the flights **112**. As the conveyor body **102** travels about the bin floor, it can navigate over uneven or otherwise irregular areas of the floor (owing to settling, non-level concrete pouring, floor features such as aeration tunnels, etc.), and effectively sweep grain despite such irregularities, owing to the flexibility in the perimeters of the flights **112**, and owing to the pivotally-connected body sections **170***a* and **170***b*. The bottom edges of the flights **112** bend in a squeegee-like fashion as they run across the bin floor, and the flexure between the hinged intermediate body sections **170***a* and **170***b* allows adjacent sections of the conveyor body **102** to tilt with respect to each other along the conveyor length. The use of one or more hinged body sections **170** (i.e., a pair of hingedly connected body sections **170***a* and **170***b*) is particularly useful to accommodate floor irregularities: since a conveyor body **102** will typically be assembled to extend 30-70 feet in length (though lesser or greater lengths are possible), a rigid conveyor body **102** might result in the flights **112** passing over low areas on the floor, thereby leaving grain behind, and/or the portions of the conveyor body **102** might "hang up" on high areas and be unable to move. Moreover, the weight of the grain in a full bin could cause undesirable stress over a conveyor body **102** having a rigid conveyor length. Beneficially, the sweep conveyor **100** depicted in the drawings has a very low center of gravity, which helps deter tipping or twisting of the conveyor body

102 along its length when it is buried in grain, and/or when it encounters irregular grain loading along its conveyor length.

At the inner body section **164**, the motor **120** (FIG. **2**) and/or gearbox **124** are appropriately chosen to provide the desired output when driving the flights **112** (FIG. **1**). The motor **120** is covered by a hinged shield **196** so that when the sweep conveyor **100** is buried in grain, the motor **120** is less likely to overheat. The motor **120** is preferably a variable frequency electric motor which is controlled to operate at an appropriate speed by a programmable logic control or other controller, though other types of motors can be used (e.g., hydraulic or other non-electric motors may be useful where totally spark-free operation is desirable, such as when the sweep conveyor **100** is used to sweep ignitable powders, though "XP-rated"—i.e., explosion-proof—electric motors will generally be suitable). Preferably, the controller monitors the speed and torque of the motor **120** and tractor unit(s) **108** to obtain a measure of grain removal, and adjusts the power supplied to each to attain a desired rate of removal. For example, if the output of the motor **120** indicates increasing torque and decreasing speed (indicating that the motor **120**, and its associated belt **114** and flights **112**, are beginning to "strain" to achieve grain removal), the tractor unit(s) **108** might be paused or slowed until the burden on the flights **112** decreases. As another example, if the output of the motor **120** is such that stalling of the flights **112** (e.g., from plugging of the sweep area **138** and/or the return area **140**, FIG. **4**) is indicated, the tractor unit(s) **108** may be stopped, and the controller may attempt to drive the motor **120** (and possibly the tractor unit(s) **108**) in reverse for a period to see if the stalling can be resolved. It is notable that the ability to independently alter the speeds of the belt/flight motor **120** and the tractor unit(s) **108**, and/or adjust the speed of one in at least partial dependence on the operating state of the other, avoids many of the drawbacks that arise where the grain-conveying drive and the floor-traveling drive of a sweep conveyor are always running together, as is common in prior sweep conveyors. For example, in many prior sweeps, when the grain-conveying drive encounters a large load of grain, it is necessary to use jacks or other lifts to lift the wheels of the floor-traveling drive off the floor to slow or halt their driving action. Otherwise, the grain-conveying drive may overload as the floor-traveling drive continues to push the sweep conveyor into the grain before the grain-conveying drive adjusts to the load.

Additional sensors may supply feedback regarding the level of grain and/or grain flow in the sump **1000**, the temperature of the motor **120**, the position of the sweep conveyor **100** about the bin floor, and other factors. Ideally, the sweep conveyor **100** may be entirely monitored and controlled at a remote station outside the grain bin, so that a "zero bin entry" system is provided.

Within the inner body section **164**, the shaft **122** (FIG. **1**) of the inner wheel **116** is supported at its opposing ends by high-strength bearings to deter deflection of the shaft **122**. While not depicted in the drawings, the rearward outer wall **142** (FIG. **2**) adjacent the inner wheel **116** (FIG. **1**) preferably curves to closely follow the path followed by the flight outer ends **130** to better avoid a "dead area" where grain might collect. It is notable that the use of the inner and outer wheels **116** and **118** to support the flight-bearing belt **114**, without the use of intermediate "idler" wheels, allows the belt **114** to sag somewhat (if appropriately tensioned). As a result, the flights **112** can drag across the floor in the sweep area **138**, allowing more thorough removal of grain.

The longer intermediate body section **168**, as best seen in FIG. **1** and in the cross-sectional view of FIG. **5**, has its forward inner wall **134** continue upwardly at a slight angle to the peak of the longer intermediate body section **168**, thereby defining a rear chute wall **198** which directs any grain falling thereon through the bars **152** of the grating **150** toward the sweep area **138** (shown occupied by a flight **112** in FIG. **5**, as with the return area **140** between the rearward inner wall **136**, the rearward outer wall **142**, the rear floor **144**, and the roof **146**). A sloped conveyor body rear top wall **200** extends from the peak to the rearward outer wall **142** to better direct grain avalanching over the conveyor body **102** toward the rear of the sweep conveyor **100**. As noted previously, rollers can be situated at the bottom of the conveyor body **102** to help support it during its travel about the bin, and one such roller **202** is depicted within the space **204** between the forward and rearward inner walls **134** and **136**. Rollers of this nature, which are preferably made of steel, can be situated at the bottom of each conveyor section between the forward and rearward inner walls **134** and **136**, with the rollers **202** being oriented to roll along planes oriented generally perpendicular to the conveyor length. These rollers **202** preferably have adjustable height, as by supporting their central shafts on screws (not shown), such that the clearance of the bottom of each conveyor section over the bin floor is adjustable. Typically, it is preferable to have the rollers **202** support each conveyor section so that the section is as close as possible to the bin floor, typically by no more than a quarter to a half an inch. FIG. **5** also depicts the aforementioned flexible flange **156**, which helps collect grain which is not swept out of the sweep area **138**. The flange **156** is sandwiched against the rear side of the forward inner wall **134** by an elongated plate **160**, with bolts (not shown) extending through the plate **160** and flange **156** to engage the forward inner wall **134**.

The shorter intermediate body sections **170***a* and **170***b* are generally constructed similarly to the longer intermediate body section **168**, save for their shorter length, and save for the (optional) hinge **172** connecting them. If a hinge **172** is included, it is preferably provided on both the rearward outer walls **142** of the adjacent body sections outside the return area **140**, as well as on the forward inner walls **134** of the adjacent body sections between the forward and rearward inner walls **134** and **136**, as with the hinges **172** seen in FIG. **5**. The barrier strip **178** "sealing" the seam defined between the hingedly connected body sections **170***a* and **170***b* is preferably formed of rubber or another elastomer, though a strong fabric (e.g., durable canvas) or other suitably flexible material may be used instead. The strip **178** extends upwardly across the rear top walls **200** of the shorter body sections **170***a* and **170***b* (against which the strip **178** is sandwiched by the plates **206**) to extend over, and be folded about, the front side edges of the shorter body sections **170***a* and **170***b*. The barrier material **178** is there held in place by the gratings **150** of the shorter body sections, whose endplates **154** sandwich the barrier material **178** against the abutting walls of the shorter body sections **170***a* and **170***b*. The strip **178** can therefore be removed and replaced when needed by unbolting the plates **206** from the rear top walls **200**, and by unbolting the grating endplates **154** from the walls.

The outer body section **166**, which bears the outer wheel **118** carrying the flight-bearing belt **114**, includes the aforementioned tensioner **180** for adjusting the tension of the belt **114** (e.g., for tightening the belt **114** when it stretches after a period of use). As previously noted, the tensioner **180** is shown in FIG. **4** as a rectangular box closely and slidably fit within the space between the forward and rearward inner walls **134** and **136** of the outer body section **166** (and between the floor **144** and roof **146** of this space as well). The tensioner wheel end **182** defines a yoke wherein the outer wheel **118** is

rotatably mounted between bearings, and the opposing tensioner adjustment end **184** bears a threaded aperture which receives the screw **186**. The end of the screw **186** is then rotatably mounted in a bearing or the like on the bridge **188** extending between the forward and rearward inner walls **134** and **136** of the outer body section **166**. A user may therefore access the end of the screw **186** via the access door **190** at the rear top wall **200** of the adjacent shorter body section **170***b*, and turn the screw **186** to drive the tensioner **180** (and thus the outer wheel **118**) along the conveyor length to attain the desired tension in the flight-bearing belt **114**. (Such an access door **190**, or at least the aperture thereof, is preferably provided near one or more ends of each body section **164**, **166**, **168**, and **170***a*/**170***b* to allow maintenance access to the interior of the body section, but the door may be welded shut—or its aperture simply omitted—where no such access is needed.)

The tractor **108**, which extends from the rear of the outer body section **166** on the tractor arm **192**, is preferably pivotable about the axis of the tractor arm **192** so that the tractor **108** can better accommodate floor unevenness. As seen in FIG. **5**, the tractor arm **192** preferably does not extend perpendicularly from the conveyor length, or more precisely, the axes of rotation of the wheels **110** do not extend parallel to the conveyor length, and are rather oriented at an angle to the perpendicular (or to the conveyor length), as this has been found to provide better traction. A high-torque electric motor **208** is controlled by the controller for the sweep conveyor **100** to drive the wheels **110** of the tractor unit **108**. The tractor arm **192** extends rearwardly from the motor **120** and wheels **110** to support the removable weights **194**, which are depicted as plates having U-shaped handles **210** at their ends. The weights **194** are mounted on the tractor arm **192** by inserting legs **212** extending from the tractor arm **192** into the U-shaped handles **210**, thereby holding the weights **194** firmly in place on the tractor arm **192** even when the tractor **108** drives forwardly when buried under grain.

The walls, ceilings, floors, etc. of the various body sections **164**, **166**, **168**, and **170***a*/**170***b* are preferably made of metal sheets/panels, e.g., 0.1-0.5 inch thick hot-rolled steel, with flanges and other reinforcing structures being formed to add strength along larger unsupported areas, or at areas experiencing greater stress.

Power is preferably supplied to the sweep conveyor **100** via lines extending upwardly within the stanchion **1004**, and leading to the sweep conveyor **100** and its belt motor **120**, tractor motor(s) **208**, etc., via appropriate rotary power transmission couplings (e.g., electrical slip rings, hydraulic rotating unions, etc.).

An exemplary sweep conveyor **100** is shown in the drawings and described above to illustrate a possible configuration and features of the invention. However, sweep conveyors in accordance with the invention can be presented in forms which differ significantly from the form of the exemplary sweep conveyor **100** shown in the drawings and described above, with different sizes, proportions, components, etc., and the functions and operation of the sweep conveyor **100** can also vary from those described above. Following is a brief review of exemplary modifications that can be made.

While the function and operation of the sweep conveyor **100** is frequently described above in relation to removal of grain from a grain bin, the sweep conveyor **100** can be used for removal of other materials from other types of bins, e.g., removal of animal feed from feed storage tanks, removal of coal from coal cribs, etc.

The sweep conveyor **100** is described as rotating about a sump pivot **104** on a bin floor, but with appropriate modification, it can sweep along non-rotary paths. For example, if the sump pivot **104** is removed and one or more tractors **108** are installed to apply a driving force along the entire conveyor length, the sweep conveyor **100** can be made to sweep along a linear path. To illustrate, the sweep conveyor **100** might be installed to rest parallel to a wall of a rectangular bin, with the ends of the conveyor length being configured to ride along rails mounted on the adjacent walls of the bin, and the sweep conveyor **100** can be driven along the rails to sweep linearly across the floor of the bin.

As noted previously, the sweep conveyor **100** may include numbers, orders, and types of body sections other than those shown (e.g., more or fewer longer and shorter intermediate body sections **168** and **170***a*/**170***b* might be incorporated in the depicted sweep conveyor **100**). Hinges **172** may be incorporated between body sections where desired, and need not necessarily be provided only between shorter intermediate body sections **170***a*/**170***b* (though providing hinges **172** between adjacent shorter intermediate body sections **170***a*/**170***b* is useful to generate a hinge body section **170** that can then be installed along the conveyor length as needed). One or more tractors **108** may be provided on body sections other than the outer body section **166** to provide driving force as desired.

Body sections may also be configured significantly differently from those shown. As examples, they need not have a pentagonal peaked cross-section (as seen in FIG. **5**), and could (for example) omit the sloped conveyor body rear top wall **200**, and instead have a single forwardly-sloping chute wall **198** extending from the rearward outer wall **142** to the rearward inner wall **136**. The external tractors **108** might be omitted, and the rollers at the bottom of the conveyor body **102** between the forward inner wall **134** and the rearward inner wall **136** could be motorized to drive the conveyor body **102** (though the external tractors **108** are preferred).

The conveyor sump pivot **104** need not take the form of a bearing fit about a stanchion **206**, and could instead (for example) take the form of a descending stanchion which fits into a bearing. While not depicted in the drawings, it is useful to provide a relatively low-friction disc (e.g., of ultra-high molecular weight PET) between the bearing **104** and the sump spider **1002**, and/or a low-friction plate at the bottom of the inner body section **164**, to reduce friction and possible metal-on-metal contact between the inner body section **164** and the sump spider **1002**.

The sump pivot **104** also need not be situated at an end of the conveyor length: body sections may be situated on opposing sides of the inner body section **164** (or more particularly on opposing sides of the conveyor sump pivot **104**), such that the conveyor length straddles the sump **1000**. In this case the flighted belt **114** might ride on the inner wheel **116** and two outer wheels **118**, one at each end of the conveyor length. (Or the motor **120** and inner wheel **116** could be situated at one end of the conveyor length, and the outer wheel **118** could be situated across the sump **1000** at the opposite end of the conveyor length, perhaps with one or more idler wheels **110** being situated at or near the sump **1000**.) On opposite sides of the sump pivot **104**, the sweep and return areas **138** and **140** would exchange locations so that the sweep area **138** at each side of the sump **1000** is always driven forwardly about the bin floor, with the return area **140** trailing. Such a sweep conveyor could, for example, extend across the entire diameter of a grain bin, and could beneficially remove grain from opposing sides of the grain bin at the same time, thereby avoiding the stresses on the bin walls that can arise from unbalanced loading. An alternative to this arrangement is to simply take two independent sweep conveyors (such as two of

the sweep conveyors **100** as seen in FIGS. **1-2**) and mount them about a common conveyor sump pivot **104**. A particularly preferred alternative version of the sweep conveyor **100** has portions of its conveyor length on opposing sides of the sump **1000**, with a length extending the full radius of the grain bin on one side of the sump **1000** (i.e., extending from the sump pivot **104** to the bin wall), and a length extending approximately half the radius of the grain bin on the opposite side of the sump **1000**. A single belt **114** drives the flights **112** across the conveyor length, with the belt **114** being driven by a single motor **120** situated on the shorter side of the sweep conveyor **100** (preferably on the outer body section situated at the end of the shorter side of the sweep conveyor **100**). Such a sweep conveyor helps to avoid the aforementioned bin wall stresses owing to unbalanced unloading of the grain bin, while only requiring a motor **120** of moderate power, size, and price. In contrast, a sweep conveyor **100** extending the full diameter of the bin typically requires a more significant motor **120** to drive the belt **114** across the entire bin diameter.

While the belt **114** and inner and outer wheels **116** and **118** are depicted as a chain and sprockets, these could take different forms, e.g., the belt **114** may assume the form of a band or cable, and the wheels **116** and **118** may assume the form of rollers (for driving the band) or pulleys (for driving the cable).

A chute **148** (preferably with an upper grating **150**) could also be provided on the outer body section **166**, with the chute **148** preferably being spaced some distance away from the conveyor outer end **106** so that the chute **148** does not open above the region where the flights **112** are still traveling to the front of the conveyor body **102**. The grating **150** need not take the form of parallel bars **152**, and could (for example) take the form of bars **152** defining a mesh. The bars **152** need not be round, and could (for example) be slat-like, preferably oriented to present a narrow edge at the top of the chute **148** to better break up any clumps of material.

The tensioner **180** can operate to adjust the location of the outer wheel **118** along the conveyor body **102** by mechanisms other than a screw **186**, e.g., via a ratcheting mechanism, or via a piston or other member driven by a spring (or via hydraulics, pneumatics, etc.) to apply tension. Alternatively, the wheel-bearing tensioner **180** might simply be moved to a desired location which yields the desired tension in the belt **114**, and might then be bolted, wedged, or otherwise affixed in place.

Apart from the foregoing features, the sweep conveyor **100** might incorporate features found in one or more of the patents listed near the beginning of this document, and/or in patents cited in (or citing to) these patents.

In summary, the sweep conveyors encompassed by this patent are not limited to the various versions described above, but rather are limited only by the claims set out below. Thus, this patent encompasses all different versions of the sweep conveyor that fall literally or equivalently within the scope of these claims.

What is claimed is:

1. A sweep conveyor including:
- a. a conveyor body having a conveyor length extending between opposing conveyor first and second ends;
- b. a pair of wheels including:
  - (1) an inner wheel at or adjacent to the conveyor first end, and
  - (2) an outer wheel at or adjacent to the conveyor second end;
- c. an endless belt riding on the inner and outer wheels;
- d. flights spaced along the belt, each flight having a length protruding from the belt between:
  - (1) a flight inner end at which the flight is affixed to the belt, and
  - (2) an opposing flight outer end;
- e. a roof extending over a first set of the flights; and
- f. a grating extending:
  - (1) from the roof, and
  - (2) over a second set of the flights, whereby material falling through the grating falls between the flights.

2. The sweep conveyor of claim **1** wherein:
- a. the conveyor body is formed of two or more body sections adjacently arrayed end-to-end along the conveyor length,
- b. the body sections include:
  - (1) an inner body section:
    - (a) situated at or adjacent to the conveyor first end, and
    - (b) wherein the inner wheel is situated on the inner body section;
  - (2) an outer body section:
    - (a) situated at or adjacent to the conveyor second end,
    - (b) wherein the outer wheel is situated on the outer body section, and
    - (c) wherein the flights spaced along the belt riding on the outer wheel are exposed from both the front and the bottom of the outer body section;
  - (3) at least one intermediate body section situated between the inner body section and the outer body section.

3. The sweep conveyor of claim **2** wherein:
- a. the inner wheel is movably situated on the inner body section, and/or
- b. the outer wheel is movably situated on the outer body section,

whereby moving the inner or outer wheel adjusts the distance between the inner and outer wheels, and thereby adjusts tension in the belt thereon.

4. The sweep conveyor of claim **2**:
- a. further including a forward inner wall extending along the conveyor length, wherein:
  - (1) a space defined forwardly of the forward inner wall defines a sweep area, and
  - (2) a space defined rearwardly of the sweep area defines a return area;
- b. wherein at least one of the body sections includes:
  - (1) at least a portion of the roof, and
  - (2) at least a portion of the grating.

5. The sweep conveyor of claim **4** wherein the roof further extends over at least a portion of the sweep area.

6. The sweep conveyor of claim **1** wherein the grating is defined by spaced bars.

7. The sweep conveyor of claim **1**:
- a. further including a forward inner wall extending along the conveyor length, wherein:
  - (1) a space defined forwardly of the forward inner wall defines a sweep area, and
  - (2) a space defined rearwardly of the sweep area defines a return area;
- b. wherein the roof extends over a portion of the sweep area, and
- c. wherein the grating also extends over a portion of the sweep area, with the roof and grating being adjacently situated along the conveyor length.

8. The sweep conveyor of claim 1 further including:
a. a forward inner wall extending along the conveyor length, wherein:
(1) a space defined forwardly of the forward inner wall defines a sweep area at which the flights are exposed from both the front and the bottom of the sweep conveyor, and
(2) a space defined rearwardly of the sweep area defines a return area;
b. a rearward inner wall extending along the conveyor length,
c. a rearward outer wall extending along the conveyor length, wherein the return area is situated between the rearward inner and outer walls, and
d. a rear floor extending between the rearward inner and outer walls beneath the return area.

9. The sweep conveyor of claim 1 further including a flexible flange extending downwardly below the conveyor body along the conveyor length, whereby as the conveyor body travels along a floor, the flange rides along the floor.

10. The sweep conveyor of claim 9:
a. further including a forward inner wall extending along the conveyor length, wherein:
(1) a space defined forwardly of the forward inner wall defines a sweep area, and
(2) a space defined rearwardly of the sweep area defines a return area;
b. wherein the flexible flange descends from the forward inner wall.

11. The sweep conveyor of claim 9 further including:
a. a rearward outer wall extending along the conveyor-length rearwardly of the belt and the flights thereon, and
b. an elongated plate sandwiching the flexible flange against the rearward outer wall.

12. The sweep conveyor of claim 1:
a. further including:
(1) a forward inner wall extending along the conveyor length, wherein:
i. a space defined forwardly of the forward inner wall defines a sweep area, and
ii. a space defined rearwardly of the sweep area defines a return area;
(2) a rearward inner wall extending along the conveyor length, wherein the rearward inner wall forwardly bounds the return area;
b. wherein the conveyor body is formed of two or more body sections adjacently arrayed along the conveyor length, each of the body sections including:
(1) a portion of the forward inner wall, and
(2) a portion of the rearward inner wall,
b. one of the body sections bears a tensioner translatably received between the forward and rearward inner walls, wherein the tensioner bears one of the inner and outer wheels thereon.

13. The sweep conveyor of claim 12 wherein a screw extends between and engages:
a. the body section bearing the tensioner, and
b. the tensioner,
whereby rotation of the screw adjusts the location of the tensioner relative to the body section bearing the tensioner.

14. The sweep conveyor of claim 12 wherein the tensioner extends between:
a. a tensioner wheel end bearing one of the inner and outer wheels, and
b. an opposing tensioner adjustment end having a screw extending therefrom, the screw being rotatably mounted with respect or one or more of the forward and rearward inner walls of the body section bearing the tensioner.

15. The sweep conveyor of claim 1 wherein each flight is:
a. rigid for a major portion of its length extending from the flight inner end, and
b. flexible for a portion of its length extending from the flight outer end.

16. The sweep conveyor of claim 1 wherein each flight:
a. is formed of a plate of flexible material, and
b. is fixed to a rigid leg extending outwardly from the belt, the rigid leg extending for a major portion of the flight's length extending from the flight inner end.

17. The sweep conveyor of claim 1 wherein at least one of the inner and outer wheels is movable along the conveyor length, whereby one or more of the wheels adjusts the tension in the belt thereon.

18. A sweep conveyor including:
a. a conveyor body having:
(1) a conveyor length extending between opposing conveyor first and second ends,
(2) conveyor front and rear sides extending along the conveyor length,
(3) a sweep area defined along the conveyor front side,
(4) a grating atop at least a portion of the conveyor front side, and over the sweep area,
(5) a return area extending along the conveyor length rearwardly of the sweep area, and
(6) a roof atop at least a portion of the conveyor rear side, and over the return area;
b. inner and outer wheels oriented to rotate about at least substantially vertical axes, wherein:
(1) the inner wheel is situated closer to the conveyor first end than to the conveyor second end, and
(2) the outer wheel is situated closer to the conveyor second end than to the conveyor first end;
c. an endless belt riding on the inner and outer wheels;
d. flights spaced along the belt and within the sweep and return areas, each flight having a length extending from the belt between:
(1) a flight inner end at which the flight is affixed to the belt, and
(2) an opposing flight outer end.

19. The sweep conveyor of claim 18 wherein:
a. the conveyor body is formed of two or more body sections adjacently situated along the conveyor length, and
b. at least two adjacent body sections are hingedly connected, whereby the hingedly connected body sections pivot with respect to each other in vertical planes.

20. A sweep conveyor including:
a. a conveyor body:
(1) having a conveyor length extending between opposing conveyor first and second ends,
(2) having a forward inner wall extending along the conveyor length, wherein:
i. a space defined forwardly of the forward inner wall defines a sweep area, and
ii. a space defined rearwardly of the sweep area defines a return area;
(3) wherein the conveyor body is formed of two or more body sections adjacently situated along the conveyor length, each of the body sections including a portion of the forward inner wall,
(4) at least two adjacent body sections are hingedly connected, whereby the hingedly connected body sections may pivot with respect to each other in vertical planes,

b. a pair of wheels oriented to rotate about at least substantially vertical axes, the wheels including:

(1) an inner wheel at or adjacent to the conveyor first end, and

(2) an outer wheel at or adjacent to the conveyor second end;

c. an endless belt riding:

(1) on the inner and outer wheels, and

(2) around the forward inner wall;

d. flights spaced along the belt and within the sweep and return areas, each flight having a length protruding from the belt between:

(1) a flight inner end at which the flight is affixed to the belt, and

(2) an opposing flight outer end.

21. The sweep conveyor of claim **20** further including a rearward inner wall extending along the conveyor length, wherein:

a. the rearward inner wall forwardly bounds the return area, and

b. each of the body sections includes a portion of the rearward inner wall.

22. The sweep conveyor of claim **20** wherein the hingedly connected body sections include lengths of flexible barrier material joined between the hingedly connected body sections.

23. The sweep conveyor of claim **21** wherein:

a. the walls extending along the conveyor length further include a rearward outer wall rearwardly bounding the return area, and

b. the hingedly connected body sections include:

(1) a set of hinge plates connected to the rearward outer walls of the body sections outside the return area, the hinge plates being pivotally pinned together, and

(2) a set of hinge plates connected to the forward inner walls of the body sections outside the sweep area, the hinge plates being pivotally pinned together.

24. The sweep conveyor of claim **23** wherein each set of hinge plates defines three or more adjacent ears with a pin extending therebetween.

25. The sweep conveyor of claim **20** wherein the conveyor body includes:

a. a roof extending the sweep area, and

b. a grating extending adjacent the roof and above the sweep area.

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